# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. | |
|---|---|---|
| N.75180A JGL | | |
| International application No. | International filing date *(day/month/year)* | (Earliest) Priority Date *(day/month/year)* |
| PCT/GB 99/00590 | 26/02/1999 | 05/03/1998 |
| Applicant | | |
| FORMULA ONE ADMINISTRATION LIMITED et al. | | |

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 2

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/00590

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 H04N7/18

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | GB 2 307 375 A (BRITISH BROADCASTING CORP) 21 May 1997 | 13,14 |
| A | see page 3, line 1 - page 4, line 7<br>see page 4, line 19 - page 5, line 19<br>see page 10, line 29 - page 11, line 2 | 1,12 |
| A | DEVLIN B F: "Radio-cameras: the key to improved flexibility in live outside broadcasts"<br>IEE COLLOQUIUM ON 'CIRCULARLY POLARISED ELEMENTS AND ARRAYS' (DIGEST NO.125), LONDON, UK, 13 JUNE 1991, pages 4/1-4, XP002104436<br>1991, London, UK, IEE, UK | 1,12,13 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 1 June 1999 | 10/06/1999 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Beaudoin, O |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/00590

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| GB 2307375 A | 21-05-1997 | NONE | |

P.D. 13-06-91
p. 4/1 - 4/4 = (4)

XP-002104436

# RADIO-CAMERAS: THE KEY TO IMPROVED FLEXIBILITY IN LIVE OUTSIDE BROADCASTS

B.F. Devlin*

## INTRODUCTION:

Mobile and portable television cameras are often used in the BBC for OB coverage of sports events, concerts and news items. They offer producers and camera operators a great deal of flexibility in the choice of camera shots, especially when used close to the action. For recorded programmes, VTRs and Cam-corders are available, but for live work the camera must be connected to a vision mixer using either a cable or a radio link.

A long cable trailing from the camera can be an incumbrance and a safety hazard, especially in sports environments, so the alternative of using a radio link is very popular, allowing the operator much greater freedom of movement. Also, if the camera is mounted on a moving vehicle it would be impossible to use a cable in such circumstances. The combination of a portable camera coupled to a radio link transmitter often powered by the same battery has become known as a radio-camera.

## TYPES OF RADIO-CAMERA SYSTEM

There are two basic types of radio-camera system. Those that use directional antennas and those that use omni-directional antennas. If a directional antenna is used, this requires that the antenna be pointed towards the receiver for the link to work. This implies either some sort of automated tracking system or alternatively a second operator to point the antenna in the required direction. The introduction of a second operator introduces new problems. The cable between the two operators in itself can become a safety hazard, especially when the cameraman is running forwards and the link operator is running backwards trying to keep his antenna on track !

Omni-directional antennas may be mounted on the camera itself and do not require pointing. Omni-directional in this case implies uniform gain in the azimuth plane. Ideally, this radio-camera would be able to cover all areas where a line of sight path is available. The practical case is often less than ideal because the transmitting antenna illuminates objects and surfaces all around, and these can give rise to spurious reflected signals, which can also be received by the distant receiver. Interference between the direct and reflected signals can affect the operation of the radio link causing distortion of the received television signal. This effect is known as multipath propagation, and the result is multipath distortion, which can largely be eliminated by the use of a directional transmitting antenna.

## BRIEF HISTORY

The major development which has made the radio-camera operation possible is the development of the frame store synchroniser which removes the need to keep the camera synchronised to the rest of the programme sources. However, most synchronisers require a clean video source, and this can be a problem in a multipath environment. The other requirements for a portable radio-camera are miniature, low power, light weight cameras and transmitters as well as high capacity portable batteries.

The choice of frequency band also effects the equipment. At low frequencies it is possible to build relatively high power transmitters, but the antenna size is large. At higher frequencies the antennas become smaller, but it is more difficult to build light-weight, high power transmitters. Very early systems used the VHF and UHF frequency bands with linearly polarised antennas, but these were very vulnerable to multipath propagation, and rarely provided consistently high quality television pictures.

With the evolution of miniature SHF radio link transmitters, the only remaining problem was that of multipath propagation. Back in 1987 at the World Athletics Championships in Rome, the Italian broadcaster RAI demonstrated a single operator system, using an omni-directional circularly polarised transmitting antenna. The success of this system prompted the BBC to carry out tests using similar antennas at 2.5 GHz and ways were found to improve the purity of polarisation. The 1988 Olympic Games in Seoul, prompted the development of an antenna at 12 GHz and this led to the introduction into service of a series of single operator systems at these two frequencies.

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## THE FM LINK

Television Outside Broadcast radio links in the SHF bands commonly use FM. Assuming a reasonable carrier-to-noise ratio is achieved, the main drawback is the effect that multipath propagation has upon it. When multipath propagation occurs, the reflected signal arrives at the receiver later than the direct signal. And, as the two signals combine in the receiving antenna, interference between them imposes a comb filter frequency response on the RF channel. The nature of this filter is dependant on the amplitude and the time delay of the reflections.

This comb filter response can have several adverse effects on the FM television signal. It can cause the appearance of spurious luminance components in the coloured areas of the picture, and can cause the colours to become brighter and dimmer, and occasionally the colours change altogether. It can also give rise to bursts of noise which can cause loss of synchronisation when the television signal is displayed. It can be extremely distressing to see bright purple grass suddenly materialise at Wembley !

## OMNI-DIRECTIONAL TRANSMITTING ANTENNA CONSIDERATIONS

The first omni-directional radio-camera antennas used in the BBC were linearly polarised dipoles, usually vertically polarised. These antennas however gave no protection from multipath propagation. If a reflection occurs, then there are several mechanisms by which it can be attenuated before it reaches the receiving antenna:

Spreading loss.
Loss caused by reflection from a lossy surface.
Loss caused by diffuse rather than specular reflections.
Loss associated with the directivity of the receiving antenna. (reflections not received on the bore sight)

These losses allow perhaps 20% - 30% of a typical outside broadcast venue to be covered using a linearly polarised transmit antenna. This, however, is not good enough for most circumstances.

If the transmit antenna is circularly polarised, advantage can be taken of the fact that the receiving antenna, which is also circularly polarised, can discriminate between left and right hand circular polarisation. This provides some resistance to multipath propagation, due to the fact that a circularly polarised wave will undergo a change of sense when it is normally reflected from a plain metal surface.

Practical reflecting objects do not cause pure specular refections, so in general the reflected wave will contain components of both senses of polarisation. The important feature is that the component with the sense that was transmitted is attenuated selectively on reflection, and this does not occur using linear polarisation. Hence if the radio-camera and a distant receiver both have the same sense of circular polarisation, the signal propagating over the direct path will be received without additional attenuation, but reflected signals will be attenuated.

The surfaces of most reflecting objects found at Outside Broadcast venues are rough in terms of the RF wavelength. The consequent scattering leads to further attenuation after two or more reflections, so the signal strength is then usually insignificant. This principle provides sufficient benefit to allow the use of a circularly polarised transmitting antenna with an omni-directional radiation pattern in the azimuth plane, and this is the key to simple hand held radio-camera operation.

With the application of chrominance AGC which reduces some of the multipath effects seen in the coloured areas of the picture allowing coverage of as much as 80-90% of the ground area to be achieved at a highly cluttered sports stadium.

In the single operator radio-camera the transmitting antenna is usually attached to the body of the camera, so it must have a fairly wide beamwidth in the elevation plane to allow the operator freedom to take shots at inclined angles. However, the radiation pattern of the antenna should be adjusted so that the ground reflection is minimised as the ground is a reflector which should always be there !

To obtain the maximum benefit from the circular polarisation of the transmit antenna, the radiation pattern is adjusted so that the purity of the circular polarisation is good, over as large a range of elevation angles as possible. If it is not possible to arrange this, then the alternative design goal of achieving pure circular polarisation at specific elevation angles is used. Antennas for specific applications such as vehicle mounting may require extra design considerations. For example, a helicopter mounted antenna must have little backfire, as reflection from the helicopter rotor blades could lead to patterning on the television picture. If the antenna is to be mounted on a racing car, for example, the racing driver would like the antenna to be as low profile, with as little wind resistance as is possible.

## RECEIVE ANTENNA CONSIDERATIONS

The receiving antenna can be mounted somewhere within the sports stadium or within the seating area of the outside broadcast venue. Therefore, it need not be very small. Dish reflector antennas are very popular for the receiving end of the link, since these are in general outside broadcast use. There is a practical trade off when using a dish antenna between using a large dish with a narrow beam which rejects a lot of multipath, and using a smaller dish with a wider beam which is easier for the operator to point. Dish antenna design is well established and the antenna should have excellent polarisation purity on boresight. It should have low side lobe levels and must be mechanically rugged enough to survive in an outside broadcast environment.

The ability to accurately point the receiving antenna is very important. If the receiving antenna goes 'off pan', then the link will be lost. Hence, a smaller, wider beam dish is used whenever practical. Easier panning can be achieved by using a different type of antenna. For example, a broad side array of four axial mode helixes can give performance similar to a small dish, but because it is possible for the operator to see through the centre of the array, it is possible to accurately pan the antenna.

## THE 2.5 GHz OMNI-DIRECTIONAL CP SYSTEM

The 2.5 GHz radio-camera system using the BBC designed omni-directional CP transmitting antenna is in use at many sporting venues, and notably the golf a couple of weekends ago. The antenna is a Lindenblad array. This is an array of four slanted dipoles fed in phase about a central vertical feed. The action of the antenna can be visualised by resolving the currents on the dipoles into a vertical dipole on the antenna's axis and a horizontal, uniform current loop around the axis. These two radiators give rise to time orthogonal vertical and horizontal far field components which will give rise to circular polarisation if their amplitudes are equal. This is arranged by altering the slant angle of the dipoles. In practice, the antenna was modelled using the Numerical Electromagnetics Code NEC 2, and a slant angle was found which would keep the axial ratio small over a wide range of elevation angles.

The azimuth and elevation radiation patterns can be seen in Figures 1a and 1b. These patterns were measured using a linearly polarised source antenna rotating about the axis of its beam, so the magnitude of undulations in the pattern displays the axial ratio. An axial ratio of 0 dB corresponds to pure circular polarisation.

In the azimuth pattern the width of the envelope of the undulations is between 3 dB and 6 dB and this corresponds to a cross polar discrimination between 15 and 10 dB respectively. The mean of this azimuth pattern is a circle showing the required omni-directional response. The mean of the elevation pattern is a lateral figure of 8, similar to the response of a vertical dipole and the deep null in the downward direction helps to suppress the ground reflection. The wide beamwidth in the elevation plane allows the integrated hand held radio-camera to be tilted. An axial ratio of 6 dB or less is maintained at all angles of elevation, which is a fundamental requirement, because spurious reflections can occur over a very wide angular range. Similar radiation patterns are maintained over the frequency range 2.2 to 2.7 GHz.

## THE 12 GHz OMNI-DIRECTIONAL CP SYSTEM

The 12 GHz radio-camera using the BBC designed omni-directional CP transmitting antenna was originally developed for the 1988 Seoul Olympic Games. The antenna is a slotted circular waveguide with a short circuit at one end and a circular polariser at the other. A circularly polarised mode is excited in the circular waveguide which is radiated by the crossed slots. The short circuit at the end is adjusted empirically so that the axial ratio in the azimuth plane is a minimum. The antenna is predominantly an end fire antenna. However, reactive elements have been added either side of the slots to try and modify the radiation patterns to reduce end fire towards the ground, and limit end fire at the top of the antenna.

The circular polarisation has been adjusted for an optimum on azimuth and on end fire. This can be seen from the radiation patterns in Figure 2. This adjustment of the radiation pattern however, leads to poor circular polarisation performance at elevation angles about 60° from the horizontal. In the azimuth pattern, the width of the envelope is between 2 dB and 4 dB. This corresponds to a cross-polar discrimination between 19 dB and 13 dB respectively. The mean of this pattern is again a circle, showing the required omni-directional response. The mean of the elevation pattern is a rather distorted lateral figure of 8, but again, a good degree of suppression is provided in the downward direction. The wide beamwidth permits tilting, but in this case the axial ratio has been optimised in the azimuth plane. An axial ratio of better than 10 dB (6 dB of discrimination) is maintained over the important range from 10° below horizontal to 45° above. Similar radiation patterns are maintained over the frequency range 11.5-13.0 GHz.

## PRACTICAL USE OF RADIO-CAMERAS

Dual operator and vehicle radio-cameras have been in use for many years and their contribution to OBs is firmly established. But the successful use of the single operator hand-held system is a relatively new phenomenon, following the development of specialised omni-directional CP antennas.

A 2.5 GHz system has now been operational for 4 years and has been used at a large number of OBs including Wimbledon, FA Cup Finals, Grand Prix at Silverstone, horse racing, golf and many major rugby matches. Since their inception for the Seoul Olympic Games in 1988, the 12 GHz CP systems have also been widely used. Notably at the 1990 Commonwealth Games in Auckland. An interesting use of the systems is in the coverage of golf, when the single operator radio-camera has its signal relayed via a caddy car, eventually reaching the mixer van via two RF links. This gives a very flexible radio-camera operation. However, it does make frequency planning for these events more difficult.

Due to the multipath resistance of these links, both systems have also been used successfully indoors for events held at the Royal Albert Hall and Earls Court, and on several occasions in television studios.

Single operator radio-camera operation has gained a great deal of acceptance amongst producers because of the improved flexibility it offers - even if the radio link fails occasionally because of excessive multipath propagation. A clear benefit of the CP system over linearly polarised systems is that the holes in the coverage tend to be narrow, and small movements of the radio-camera restore the received signal.


## ACKNOWLEDGEMENTS

The author wishes to acknowledge the permission of the Director of Engineering of the BBC to publish this paper. Also, contributions to this work are acknowledged from staff of BBC Engineering Research Department and BBC Television Outside Broadcasts.


BFD/EEMM
c:bfd/iee
6.6.91

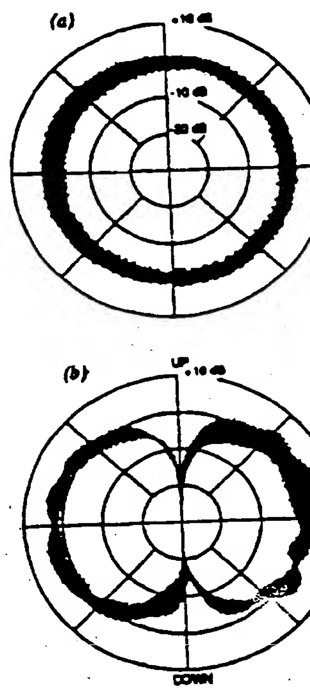


*Fig. 1 - Radiation patterns for the 2.5 GHz antenna*
*(a) Azimuth plane*
*(b) Elevation plane*

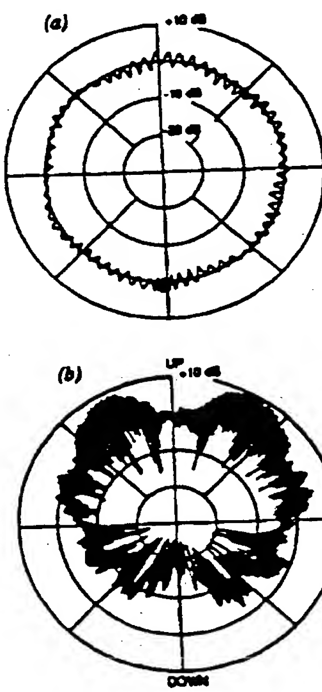


*Fig. 2 - Radiation patterns for the 12 GHz antenna*
*(a) Azimuth plane*
*(b) Elevation plane*

# (12) UK Patent Application (19) GB (11) 2 307 375 (13) A

(43) Date of A Publication 21.05.1997

(21) Application No 9523700.4

(22) Date of Filing 20.11.1995

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(51) INT CL$^6$
H04B 7/08

(52) UK CL (Edition O )
H4L LDDSX L1H10

(56) Documents Cited
GB 2244189 A GB 2196211 A GB 2112253 A
EP 0124319 A1 US 3860872 A

(58) Field of Search
UK CL (Edition O ) H4L LDDRS LDDRX LDDSX
INT CL$^6$ H04B 7/08 , H04L 1/06
ON-LINE : WPI

## (54) Mobile Radio Communication System with Diversity Reception

(57) The system comprises a mobile station (2) which carries an antenna (4). This anterna is for transmitting a signal to a base station to which a variety of fixed anterna (6) are connected. The mobile station moves within a predetermined area and transmits signals to the fixed antennas. The fixed anternas provide the base station with the signals they receive. Periodically, the mobile station transmits a known signal. The base station includes means to determine over a predetermined period of time which of the fixed anternas is receiving the said known signal with the best quality from the mobile station and also includes means to switch reception to one of the fixed antennas in dependence on the result of the determination.

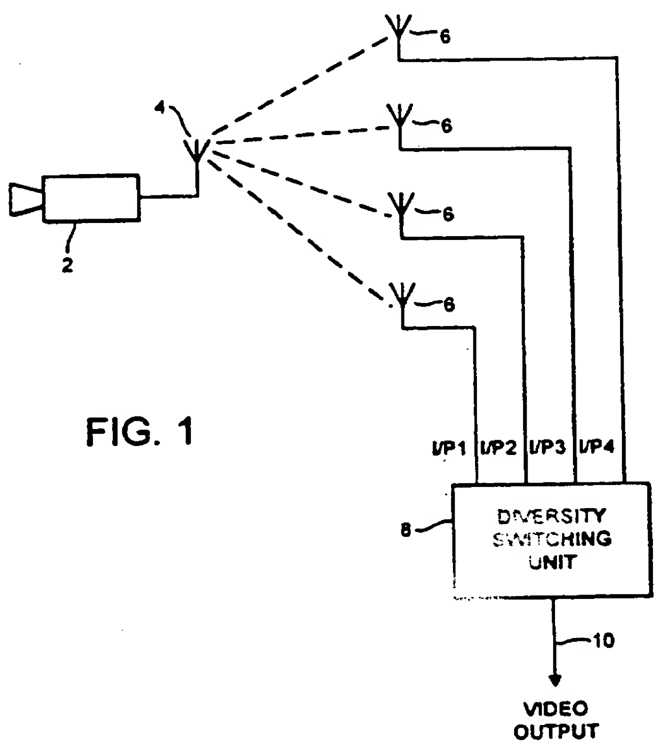



FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 307 375 A

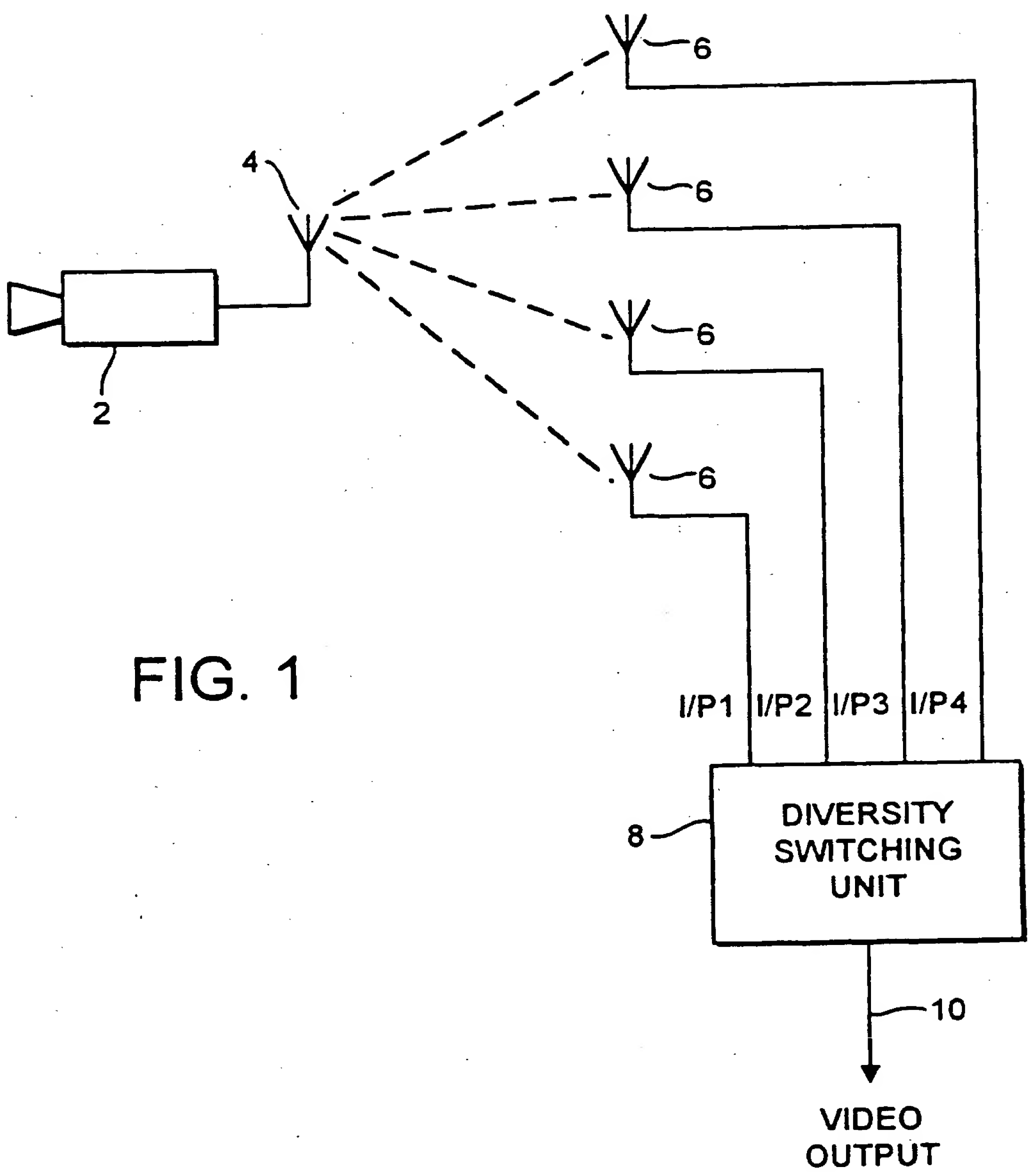

4
2
6
6
6
6
I/P1
I/P2
I/P3
I/P4
8
DIVERSITY
SWITCHING
UNIT
10
VIDEO
OUTPUT

FIG. 1

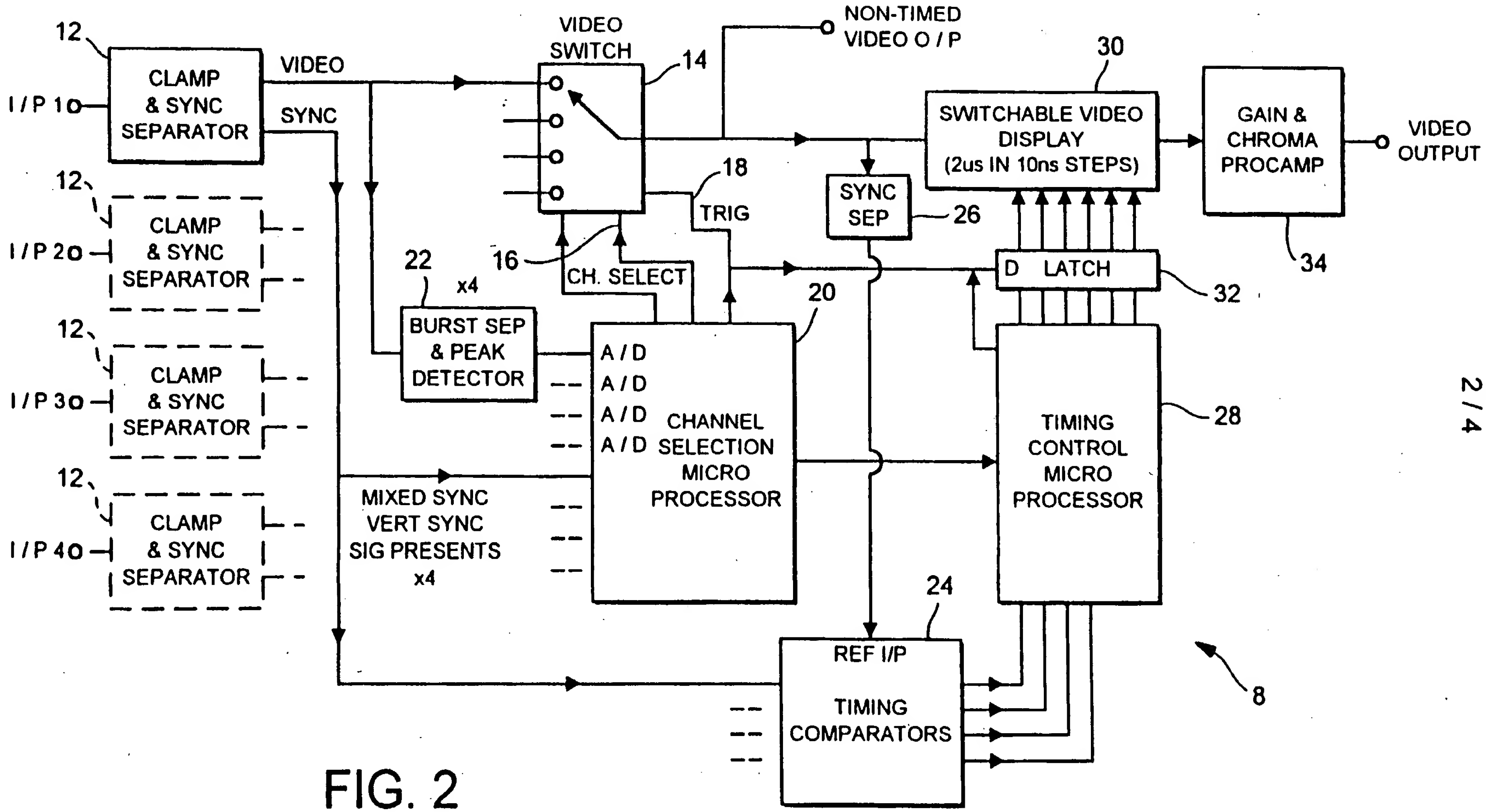
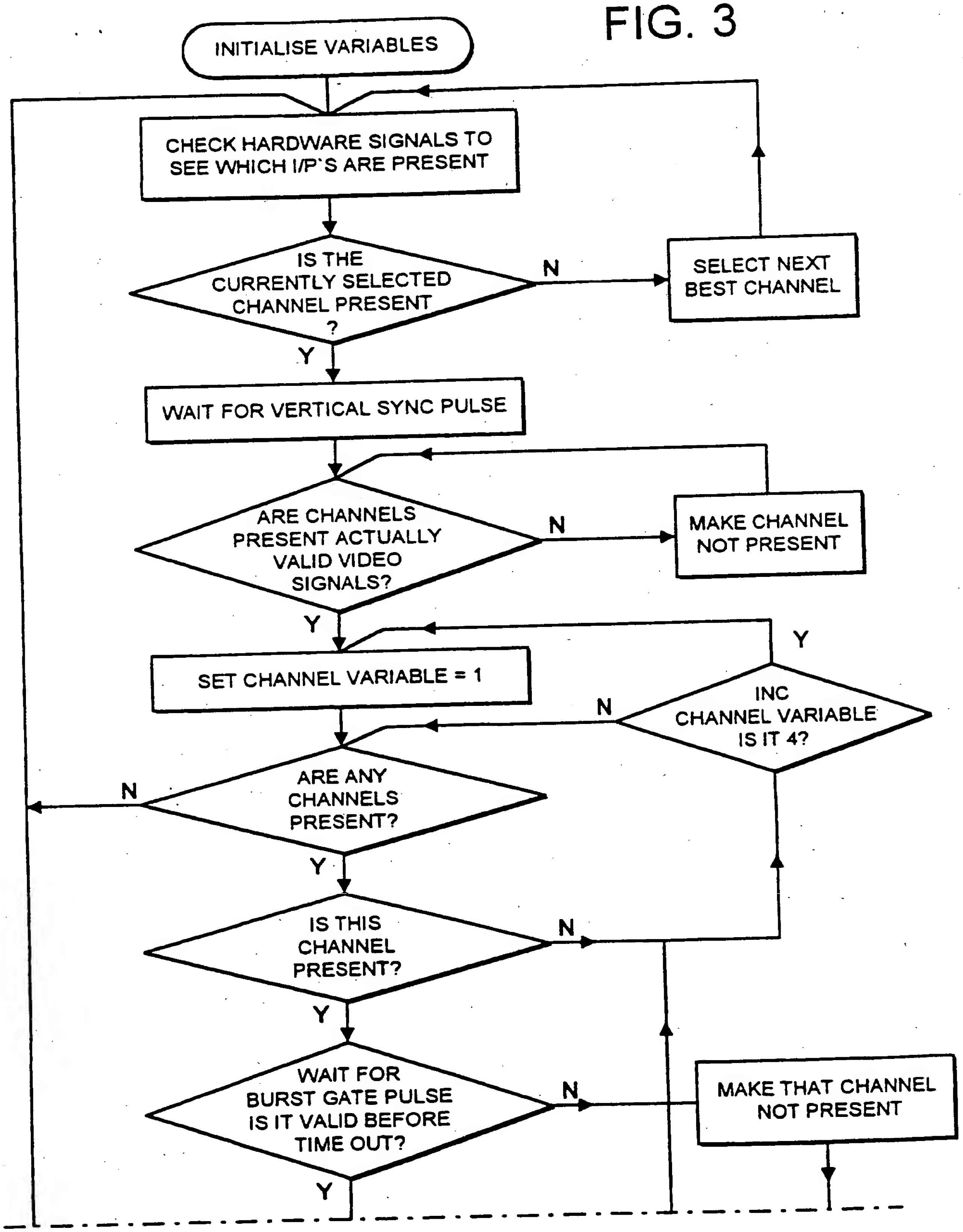

12
I/P 1
CLAMP & SYNC SEPARATOR
I/P 2
I/P 3
I/P 4
VIDEO
SYNC
VIDEO SWITCH
14
16
CH. SELECT
18
TRIG
22
x4
BURST SEP & PEAK DETECTOR
MIXED SYNC
VERT SYNC
SIG PRESENTS
x4
A / D
CHANNEL SELECTION MICRO PROCESSOR
20
NON-TIMED VIDEO O / P
SYNC SEP
26
SWITCHABLE VIDEO DISPLAY (2us IN 10ns STEPS)
30
D LATCH
32
TIMING CONTROL MICRO PROCESSOR
28
REF I/P
TIMING COMPARATORS
24
GAIN & CHROMA PROCAMP
34
VIDEO OUTPUT
8

FIG. 2

FIG. 3


INITIALISE VARIABLES
CHECK HARDWARE SIGNALS TO SEE WHICH I/P'S ARE PRESENT
IS THE CURRENTLY SELECTED CHANNEL PRESENT ?
N
SELECT NEXT BEST CHANNEL
Y
WAIT FOR VERTICAL SYNC PULSE
ARE CHANNELS PRESENT ACTUALLY VALID VIDEO SIGNALS?
N
MAKE CHANNEL NOT PRESENT
Y
SET CHANNEL VARIABLE = 1
Y
INC CHANNEL VARIABLE IS IT 4?
N
ARE ANY CHANNELS PRESENT?
N
Y
IS THIS CHANNEL PRESENT?
N
Y
WAIT FOR BURST GATE PULSE IS IT VALID BEFORE TIME OUT?
N
MAKE THAT CHANNEL NOT PRESENT
Y

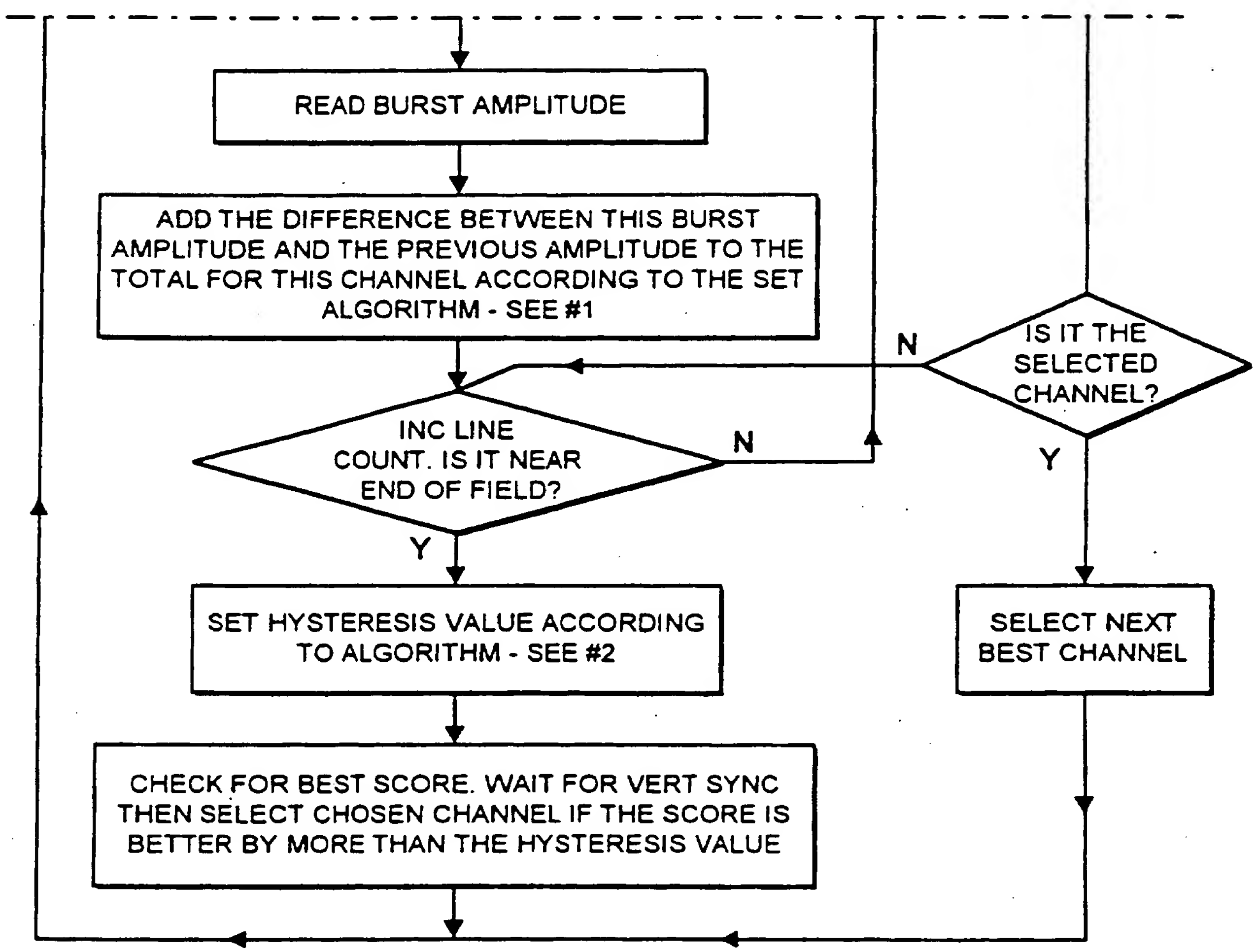

READ BURST AMPLITUDE
ADD THE DIFFERENCE BETWEEN THIS BURST AMPLITUDE AND THE PREVIOUS AMPLITUDE TO THE TOTAL FOR THIS CHANNEL ACCORDING TO THE SET ALGORITHM - SEE #1
IS IT THE SELECTED CHANNEL?
N
Y
INC LINE COUNT. IS IT NEAR END OF FIELD?
N
Y
SET HYSTERESIS VALUE ACCORDING TO ALGORITHM - SEE #2
SELECT NEXT BEST CHANNEL
CHECK FOR BEST SCORE. WAIT FOR VERT SYNC THEN SELECT CHOSEN CHANNEL IF THE SCORE IS BETTER BY MORE THAN THE HYSTERESIS VALUE

FIG. 3 CONT

2307375



# DIVERSITY SWITCHING UNIT FOR MOBILE COMMUNICATION LINKS

This invention relates to mobile communication systems and in particular to communication systems of the type which are used with mobile radio cameras or cordless cameras.

Radio cameras or cordless cameras have been developed over a period of years and are used very effectively for television outside broadcasts and also in studios where appropriate.

There are two main problems which have traditionally limited the range and flexibility of radio cameras. These are:

a) multipath propagation caused by reflections from surrounding surfaces, including reflections from the ground and from the ceiling in studios;

b) obstruction of the clear line of sight between the camera and the receiver caused by structural barriers or temporary obstructions such as vehicles and people, including the camera operator.

There are a number of systems in service at the moment all of which concentrate on minimising the effect of multipath distortion. These are summarised below:

1) radio cameras which incorporate directional circular polarised antennas. Signals transmitted from these are received on amanually panned directional antenna which is also circularly polarised;

2) radio cameras of the type described in our British Patent No. GB 2196211. In this the radio camera carries a cluster of directional horn antennas, typically six, grouped together so that their beam widths overlap to give 360° coverage. The system is video based and the

principle of operation is that a test signal is generated in the camera and is transmitted on each of the antennas in turn during a field blanking interval. The receiver analyses the test signal to decide which antenna is giving the best output and relays this information back to the camera so that the appropriate antenna can be used for transmission of the following video field.

3) Ikegami PTR 1 System. This employs an active electromagnetic tracking system to keep a directional antenna in the camera pointing towards a base receiver. The antenna at the base receiver is manually panned and incorporates a transmitter to convey the tracking information back to the camera.

All the above systems operate with a single radio link path between the camera and base reception point for transmission of the video signal and, as already stated, this path can suffer from multipath distortion and from obstruction. Very elaborate methods have been employed to overcome multipath and although these have minimised the problem none have eliminated it completely.

None of the current systems overcome the problem of obstructions between the transmitting antenna and the receiver. One of the most common causes of obstruction is the camera operator himself obstructing the primary transmission path with his own body. Also, none of the current systems provide a solution for the seamless transfer of transmission from one arena of activity to another or one room to another as the mobile camera moves.

Another problem, in particular with the system described in our British Patent No. GB 2196211 is additional weight caused by having a cluster of antennas and the associated switching circuitry mounted on the camera.

We have appreciated that many of the drawbacks of the above systems can be overcome by using a system with several fixed receivers, strategically placed, thereby providing a number of radio link path options. The mobile camera is provided with a broad beamwidth antenna. Signals received at each receiver are assessed for degradation and the receiver giving the best quality signal is selected.

It will be appreciated that the path lengths between the camera and the various receivers will vary as the camera moves. It is therefore necessary to measure the time differences between the inputs and to switch in an adjustable delay to ensure that re-timing of the selected output follows smoothly on from the previous receiver output.

Also, there may be varitions in the signal levels of the demodulated signal and the chroma levels for a video signal. A preferred embodiment of our invention therefore corrects for these.

Preferably, a number of audio channels, typically two, will also be switched along with each video signal.

Because a number of radio link paths are available the receivers can use fixed wide beam antennas, on the basis that at least one of these will be receiving a signal relatively free from multipath distortion at any one time. By the same token, these antennas can be positioned anywhere and as unobtrusively as possible provided that at least one has a clear line of sight to the radio camera at any one time.

A system using this idea should allow radio camera coverage at very complex venues, eg. indoors with the camera moving from one room, down a corridor to another room. A second antenna would be provided to cover each

discrete area and there would be a range such that all the areas overlap. Switching could then provide continous and unterrupted coverage for the entire area.

It will be appreciated that a system such as this requires very little modification to a standard camera and thus the increase in size, weight, and power consumption is minimised.

The invention is defined with more precision in the appended claims to which reference should now be made.

A preferred embodiment of the invention will now be described in detail, by way of example, with reference to the appended drawings in which:

Figure 1 shows a block diagram of a radio camera system emboding the invention;

Figure 2 shows a block diagram of the diversity switching unit of Figure 1; and,

Figure 3 shows a flow diagram of the operation of the diversity switching unit of Figure 2.

Figure 1 shows the total system in which the invention operates. This comprises a mobile and portable radio camera 2 which transmits a video signal representing the scene at which the camera is pointed via a broad beamwidth antenna 4.

A total of, in this example, four broad beamwidth receivering antennas 6 are provided at various points around the area in which the camera is being used. In some situations it will be necessary to have more than four antennas and in others fewer will be required. At least 2 will always be needed for the invention to operate.

The signals received by the four antennas 6 are all fed to a diversity switching unit 8 which monitors the received quality of each signal in turn and then selects

the signal which has been least degraded by multipath distortion and obstruction. This signal is switched to the video output 10 and can then be used as desired. The four inputs to the diversity swiching unit 8 are labelled I/P1 to 4 respectively.

Figure 2 which shows the detail of the diversity switching unit 8 shows the four video inputs I/P1, I/P2, I/P3, and I/P4 from the four antennas. Each input is first fed to a clamp and sync separator 12 which has a video output and a sync output. The sync output comprises the vertical and horizontal synchronising waveforms from each video signal.

The video signals from the clamp and sync separator units 12 form the input to a video switch 14. This is responsive to two channel selection bits 16 and a trigger signal 18 to cause the video switch to select one of the video inputs. The channel selection bits and the trigger signal are both generated by a channel selection microprocessor 20.

The outputs of the clamp and sync separator units 12 are also supplied to four respective burst separator and peak dectector circuits 22. These are responsive to the colour burst transmitted at the start of each line of a field of a video signal to produce an output signal dependent on the peak amplitude of the colour burst. The colour burst is a reference signal used by the automatic gain control circuitry in television receivers to ensure that the signal levels displayed are substantially the same on each line. It is transmitted at the start of each line of the video signal.

The peak signals from each of the burst separator and peak dectectors 22 are all inputs to the channel selection microprocessor 20.

The microprocessor 20 keeps a score or count signal for the variation in burst amplitude for each channel from line to line during a video field. Each signal may be measured on consecutive lines or on every nth line in dependence on the processing power available and the number of receiver inputs being used. At the start of each field the score or count signal for each channel is set to zero. The score for each channel is then compiled by comparing the burst amplitude of a line with the previously measured burst amplitude for a line on the same channel. It could be arranged to measure each burst amplitude for every line but in some circumstances it may be preferable to use alternate lines or every third or fouth line. This will depende on the number of channels being used.

The score for a channel is complied by looking at the burst amplitude for a particular line. If this is, for example, 1% lower than it was on the previously measured line then a count of one is added to the total score for that partiuclar channel. The same score would be added if the burst amplitude was 1% higher. If the difference is 10% then a score of 10 would be added. Thus, by the end of a field the channel selection microprocessor will have built up scores for each channel based on the amount by which the burst amplitudes has varied over that field.

One problem with this approach is that a channel with a steady but low burst level will achieve a similar score to a channel with a steady but correct burst amplitude. Clearly the latter would be the preferable signal to use. To overcome this problem a correction is applied based on the absolute burst level. This is achieved by adding a fixed additional score based on the amount of deviation

from the correct burst amplitude. This again is calculated over the whole field and is then added to the originally complied score. This ensures a channel with good chroma amplitude will always achieve a better score than one with a steady but incorrect chroma amplitude. The exact way in which the score was compiled may be modified in dependence on the exact situation in which the radio camera is being used. Thus in some circumstances a steady but incorrect burst amplitude may still be considered better than a burst which is varying with respect to the correct level.

At the end of each field the channel with the lowest score signal is selected. To prevent rapid switching between similar channels a new channel will only be selected if it is better than the channel currently being used for reception by an amount greater than a hysteresis value which is preset.

The hysteresis value is set in dependence on the lowest channel score from the previous field and on the setting of a user input such as a thumb wheel switch which allows control over the sensitivity of the system.

The best hysteresis setting will be dependent on the lowest score because the score signal will vary according to the number of channels actually present and therefore the itervals between burst measurement for each channel. The more channels there are present the fewer times they will be sampled during a field. For example, the most sensitive setting is based on the lowest score divided by four with a minimum value set at, e.g. 10. The least sensitive value is set by dividing the lowest score by two with a minimum value of 50. This is then compared with the difference between the selected new channel and the

current channel and, if that difference exceeds the hysteresis value the new channel is selected.

As will be seen from Figure 2 the channel selection microprocessor 20 also receives sync. signals from the clamp and sync. separator units 12. These are required to ensure that switching between the four received video signals only occurs in field blanking intervals. Thus, the channel selection microprocessor operates every field blanking interval to generate two channel selection bits corresponding to the channel to be used and a trigger signal to cause the video switch 14 to switch from the current channel to the new channel. This happens when the scoreshave been compiled for each channeland it is indicated that it is necessary to change betweento a different channel for the next video fiel.

The sync signals from the clamp and sync seperator units 12 are also fed to a set of timing comparators 24. The sync signals are compared with the sync signals on the currently selected video signal output by the video switch 14. These signals are extracted from the selected video signal by a sync separator 26. The differences in timing between the currently selected video signal and the four received video signals are then fed to a timing control microprocessor 28. This also receives a signal from the channel selection microprocessor at the end of each field representing the currently selected channel for reception.

The microprocessor 28 generates a set of bits to control a switchable video delay 30 which is provided in the path of the selected video signal. These bits are held on a latch 32. When a new channel is to be selected the channel selection signal from the channel selection microprocessor 20 changes thus causing the output bits of the timing control microprocessor 28 to change to

represent the difference between the selected channel and the channel currently being used. When the trigger signal is generated is by the channel selection microprocessor the set of bits representing the new delay are latched and form the input to the switchable video delay thus altering the delay and causing the newly selected video signal to follow smoothly from the previously selected signal. The switchable video delay is typically a delay of up to two microseconds in steps of ten nanoseconds.

The use of this delay prevents any visible disturbance on the video output signal.

In addition to the above processes the channel selection microprocessor also monitors received signals to determine whether or not an input signal is valid. At the start of every field a simple check is made to determine whether anything is present on each of the inputs. Then, a further careful check lasting four lines per input signal is made to ensure that it is a valid video signal containing sychronising signals and a colour burst and it is not just receiver noise.

Furthermore, simple checks are also made (preferably one per line) to ensure the continued presence of each signal. If at any time the selected signal disappears then the channel selection microprocessor operates to switch immediately to the channel with the next best previously measured score.

When a new channel is selected the switchable video delay 32 is gradually adjusted back towards its mid position by making small (10 nanoseconds) adjustments during each field interval towards the mid position.

Finally, a processing amplifier 34 is provided to correct automatically the video and chroma amplitudes of the selected video signal regardless of the input signal

levels. This effectively removes the need for any further auto correcting devices since the video output will then be substantially constant whichever receiver input is selected. The range of auto control is quite wide being approximately ±6db per video level and chroma level.

The algorithm used to analyse multipath distortion, the hysteresis level, and the sampling times can all be changed to meet specific requirements or adapted to be used with other video formats simply by changing the microprocessors. Alternatively, the unit could be provided preset to operate with a selection of video formats and different algorithms, hysteresis values, and sampling times. The performance of the unit can be monitored by connecting an external PC using a serial data link.

The operation of the Figure 2 can also be understood with reference to the flow diagram of Figure 3. This shows the operation of the circuitry of Figure 2 in a convenient form in the manner discussed above. The tests for presence of any channels, and then for the presence of individual channels during each field are illustrated in this.

It will be appreciated by the skilled man that the above embodiment can be implemented in dedicated hardware or with a combination of hardware and software as illustrated above. The principles described above can be used with any radio link and are not limited to use with radio cameras or to any particular type of radio system or antenna. For example, the receiving antennas used could be designed to give very specific patches of coverage and then arranged so that a number of patches overlap to give continuous uninterrupted coverage. Thus the system would

only switch between antennas as the mobile camera moves from one patch to another.

The system has here been described with reference to the PAL transmission system. However, it could be used with any other transmission system such as NTSC or one of the emerging HDTV and Digital Television formats.

**Claims**

1. A mobile radio communications system comprising a mobile station carrying an antenna for transmitting a signal to a base station and moving within a predetermined area and a plurality of fixed antennas placed at predetermined positions around the area within which the mobile station moves, the fixed antennas all being coupled to the base station to provide the base station with the signals they receive, the mobile station comprising means to transmit periodocally a known siganl, the receiving station comprising means to determine over a predetermined period of time which of the fixed antennas receives the known signal with the best quality from the mobile unit and means to switch reception for the following period of time to one of the antennas in dependence on the result of the determination.

2. A mobile radio communications system according to claim 1 in which the determining means at the fixed station measures the quality of the received known signal by determining its total variation in amplitude over the predetermined period of time.

3. A mobile radio communications system according to claim 2 in which the determining means also compares the amplitude of the recieved known signal with the known amplitude of that signal.

4. A mobile radio communications system according to any preceding claim in which the switching means only operates to select a different antenna to the one currently

selected when the quality of the known signal received by one of the antennas exceeds that of the currently selected antenna by a predetermined amount.

5. A mobile radio communications siganl according to any preceding claim in which the mobile station comprises a television camera and the known signal comprises a portion of the video signal produced by the camera.

6. A mobile radio communications system according to claim 5 in which the known signal comprise the colour burst signal provided in each line blanking interval of the video signal.

7. A mobile radio communications system according to claim 5 or 6 in which the predetermined period of time comprises a video field period.

8. A mobile radio communications system substantially as herein described with reference to the accompanying drawings.

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| **Patents Act 1977**<br>**Examiner's report to the Comptroller under Section 17**<br>**(The Search report)** | Application number<br>GB 9523700.4 |
| **Relevant Technical Fields**<br><br>(i) UK Cl (Ed.O) H4L (LDDSX, LDDRS, LDDRX)<br>(ii) Int Cl (Ed.6) H04B (7/08) H04L (1/06) | Search Examiner<br>P S DERRY<br><br>Date of completion of Search<br>22 JANUARY 1996 |
| **Databases** (see below)<br>(i) UK Patent Office collections of GB, EP, WO and US patent specifications.<br><br>(ii) ONLINE: WPI | Documents considered relevant following a search in respect of Claims :-<br>1-7 |

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